THE VETERINARY JOURNAL

EDITORS: T. DALLING, *M.A., M.R.C.V.S.* J. McCUNN, *M.R.C.V.S., L.R.C.P.*

Vol. 104 March, 1948 No. 3

EDITORIAL

ANIMAL DISEASE CONTROL

We have drawn attention on several occasions to the importance of healthy livestock, not only in this country but throughout the world. It is becoming more obvious every day that the shortage of animal products in the food supply of the world must be remedied in order that the human population may receive a suitable and adequate diet. The scarcity of foodstuffs of animal origin may be in part due to a lack of the necessary numbers of animals in different parts of the world, especially those animals suitable for the production of the necessary food materials. If this be so, the remedy must be long term, for the increase of livestock can be accomplished only after a considerable period of time, given careful planning and the necessary operation of such plans. Many factors have to be taken into account, not the least important of which is the climatic and feeding conditions available in the different countries. On the other hand, the attention of all concerned must be directed to the considerable losses in the existing stocks and in their yields both of meat and milk from conditions, some of which, at least, can be prevented. Disease continues to cause much loss and low yields of animal products in those animals which survive. The veterinary profession has much to its credit in elucidating the causes of some of the important scourges in all countries and in elaborating methods of control. It is freely admitted that there is still much to be done in both directions: but it would seem reasonable to expect that methods of control of the various conditions, agreed by veterinary authorities, should be put into operation to the greatest possible extent. The application of such methods may present difficulties, but with the necessary collaboration of all concerned it should be possible to devise the ways and means, not only in this country but throughout the world, of agreeing on procedures which would lead to the suppression of some of the major afflictions of livestock. We believe that much good would accrue from widespread discussions by all interested parties and we hope that such discussions will be organised.

XUM

GENERAL ARTICLES

FOWL CORYZA: TREATMENT BY IODINE

By W. M. McKAY, Ph.D., M.R.C.V.S.
Iodine Educational Bureau, London.

ALTHOUGH usually accompanied by a low mortality, coryza is a source of considerable financial loss and anxiety to the poultry industry. Recently the disease has become increasingly prevalent with, at times, a virulence so marked as to make its differentiation from Newcastle disease a matter of some difficulty.

Coryza is an acute contagious inflammatory disease of the upper air passages and air sinuses characterised by a thin watery nasal discharge and watering of the eyes. The discharge may become sticky, very profuse, and have an offensive odour. It is common to find only one eye badly affected, the eyelids being glued together, thus allowing the secretion to accumulate and make the eyelids bulge. There is considerable respiratory distress, with noisy breathing, frequent coughing and sneezing. The disease is highly infectious and spreads with great rapidity. Few birds actually die from it, but culling and destruction of a high proportion of an infected flock is inevitable and involves heavy financial loss.

Etiology

Various workers, de Blieck (1932), Nelson (1932), Schalm and Beach (1934) and Delaplane and Stuart (1934, 1936), have reported outbreaks of coryza in poultry from which they have isolated a hæmophilic bacillus (*H. gallinarum*), which was shown to reproduce the disease on inoculation into healthy experimental fowls.

Beach (1944) states that the coryza-like infection produced by inoculation of culture is of a shorter duration than that induced by the inoculation of exudate. The question has therefore arisen whether *H. gallinarum* alone is responsible. Schalm and Beach failed to demonstrate a second pathogen in nasal exudate, but Nelson (1938) refers to both a culture-induced form, which is of rapid onset and short duration, and an exudate-induced form as representing two types of the condition. He stated that the hæmophilus bacillus was present in both types, but reported that in the latter type, of slow onset and long duration, he found minute bodies which he termed "coco-bacilliform."

Other workers have reported the association of a virus (Delaplane, 1943). The complete etiology is therefore still indefinite. In the present series of experiments no attempt was made to differentiate the causative agent, and diagnosis of a coryza-like condition in the treated flocks was based on clinical and gross *post-mortem* findings.

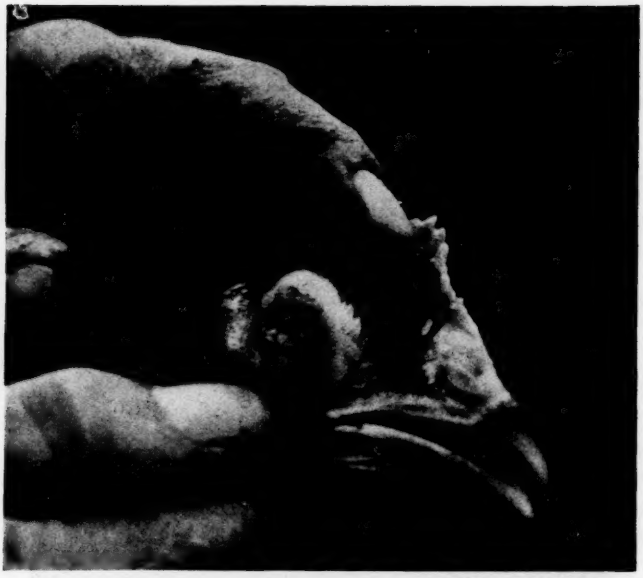
The hæmophilus is a small rod-like body which, in common with others of its group, does not grow in pure culture without the presence of hæmoglobin. Non-motile, non-sporing, non-capsulated, Gram negative and ærobic, it is an obligatory parasite and has not been found outside the animal body. Hæmophilus bacilli stain less easily with the usual aniline dyes than do some other bacilli, but they can

XUM

Affected bird; showing dejected appearance, ruffled feathers, pallid wattles, comb and face.

Mouth of affected bird showing irruption of dried inspissated pus into the mouth from the infected sinus on side of face.

Plate I—Article by W. M. McKay.



Infected eye with dry, cheesy pus.

Head of a sick bird showing swollen, infected sinus on side of face and dried discharge at nostrils.

Plate II—Article by W. M. McKay.

XUM

be readily demonstrated with ten per cent. aqueous fuchsin or with Löffler's methylene blue. Organisms belonging to the same group are: *H. influenzæ suis* of swine influenza; *H. pertussis*, the organism associated with whooping-cough; *H. duplex; H. ducreyi;* and *H. hæmoglobinophilus.*

For growth, *H. gallinarum* requires the V. C. and X growth factors as well as the generic requirement of hæmoglobin. The best medium for its isolation is nutrient agar to which sterile blood is added.

Difficulty of Control

Although the disease occurs under all types of management, it spreads with greater rapidity and is more difficult to control in intensively kept birds. This is because the disease is a respiratory one and highly infectious; because large numbers of birds are usually housed together in close proximity, with consequent high humidity and high atmospheric temperature; and because the infected and non-infected birds drink out of the same communal water container. These conditions are conducive to rapid spread of the trouble and are especially accentuated in the battery system of management where birds are housed in cages tier upon tier. Imagine, for example, an outbreak of influenza in a community of two thousand people living permanently in a cinema theatre, never out in the open air, sleeping side by side and eating from the same feeding utensils. The circumstances in a battery are not dissimilar. Isolation of infected birds is impossible and the very formidable difficulties of control are not lessened by the constant admission of fresh susceptibles.

In this type of management feeding is often on the caféteria system, that is, dry mash continuously in front of the birds, lending itself to continuous infection and possibly contributing to the primary irritation of the respiratory mucosa. Also, under these conditions vitamin deficiencies more frequently occur. Some workers have suggested certain predisposing factors such as poor ventilation, overcrowding, vitamin " A " deficiency under battery conditions. There is a continuous cycle of susceptibles since the common custom is to introduce fresh batches of day-old chicks weekly, as the other batches mature, without sufficient time for adequate disinfecting and isolation.

Control in the past has usually been based to a large extent on depopulation of the infected battery houses, with, in many cases, serious financial loss from cessation of contracts. Under extensive methods of poultry keeping the disease is also common in young growing stock, frequently manifesting itself when the birds are moved from brooder conditions to night arks, fold units or more permanent quarters, and again the disease has usually proved refractory to the usual control measures.

Treatment

Heretofore, the chemical treatment of coryza has been difficult and unsatisfactory. Delaplane and Stuart (1941) tried three sulpha-drugs but found them toxic in amounts sufficiently high to protect but not to cure. When given in

curative doses, higher than the birds would voluntarily take in their mash, marked improvement resulted at the end of the second day. But these high doses had to be administered individually, a procedure quite out of the question with large numbers of birds.

During the summer and autumn of 1947 opportunity arose for the writer, in collaboration with Professor Dalling and the staff of the Veterinary Laboratory of the Ministry of Agriculture, to treat several severe outbreaks of fowl coryza with iodine applied as vapour in the atmosphere and in solution added to drinking water.

Various considerations prompted the use of iodine. Iodine vapour as an aerial disinfectant has been advocated by many writers. Actual tests by Raymond (1946) against air-borne bacterial particles showed that iodine vapour at a readily tolerable concentration of 0.1 mg. per cubic foot of air gives a rapid kill of freshly sprayed salivary organisms at humidities above 50 per cent. The relative humidity in poultry houses is almost always above 50 per cent.

The purifying effect of iodine on water is well known. Experiments by Renshaw (1943) amply prove that one part of "free" iodine in 20,000 parts of water will kill all pathogenic organisms. This concentration of iodine was therefore adopted for the poultry drinking water in these investigations. Not only was it considered sufficient to kill the germs in the water itself, but it would materially augment the birds' iodine intake and thereby increase general resistance to infection. Further, it seemed not unlikely that water thus iodised would assist in clearing the nostrils and air passages, and reduce the gross infection contained in the masses of nasal discharge when the beak is immersed at the time of drinking.

In practice, a "free" iodine concentration of approximately one in 20,000 is achieved by adding one teaspoonful of Lugol's solution to every gallon of drinking water. Lugol's aqueous solution of iodine (five grammes of iodine and ten grammes of potassium iodide dissolved in 100 c.c. of water) is easy to make, readily obtainable, and relatively cheap compared with alcoholic tincture of iodine.

Iodine Applied at Five Centres

FARM 1 (Buckinghamshire).—A holding of 20,000 birds, of all ages from one day to twelve weeks, with a history of repeated and troublesome outbreaks of coryza over the past few years. In spite of persistent attempts, no drug treatment had been found effective. Measures of control were eventually confined to stopping the admission of fresh susceptibles into already infected premises. Battery house and first cooler, where most of the infection existed, were emptied for thorough disinfection and allowed to stand empty for some time. Fresh stock were then introduced. Premises treated in this way remained free from infection for varying periods, but in the long run always became re-infected. Furthermore, having one or more units of the installation continually out of commission was not only wasteful but very inconvenient.

In the first instance iodine treatment was applied to the following five infected groups comprising approximately 7,000 birds in all.

Premises	Capacity Cubic Feet	Number of Chicks	Age in Weeks	Iodine Vapour Dishes
Battery Brooder A ...	12,000	3,400	1-4	6
Cooler A	7,500	1,200	4-8	4
Cooler B	4,410	500	4-8	2
Cooler C	5,250	1,200	4-8	2
Cooler D	6,720	600	4-8	5

(A battery houses chicks up to four weeks old and has a drawer temperature of 90 deg. F. and a room temperature of 70 deg. F. A cooler contains older chicks in cages and has a room temperature of 65 deg. F.)

Identical premises housing approximately the same number of similarly infected chicks were kept as control. The drinking water supplied to each of the five treated groups was iodised to the degree already stated, namely, one teaspoonful of Lugol's solution to every gallon of water. In addition, small shallow open dishes (saucers would suffice), each containing about ten grammes of resublimed iodine, were placed at selected points on the roof cross-beams. As indicated above, one dish was provided for approximately every 200 cubic feet of air space except in Cooler D where the considerably lower temperature required more initial material at a greater number of points to give iodine concentration roughly equivalent to that in the other coolers. The temperature and humidity of the various rooms effectively vapourised the resublimed iodine and necessitated refilling the dishes every three or four days.

Results.—The beneficial effect of iodine became apparent almost at once. Before treatment, 40 to 50 cases of coryza were counted in each batch of about 800 chicks regularly removed every week from the battery to Cooler A. After a few days of iodine treatment this incidence of 5-6 per cent. began to fall and continued to fall progressively until at the end of six weeks only three or four cases were encountered in the weekly lots of 800 or 900 chicks leaving the battery for the coolers.

During this time infection in the untreated control groups remained severe, 40 to 50 cases being found every week among the chicks due for removal from battery to cooler. At this point (six weeks after commencement of the experiment) iodine was applied in similar fashion to the control group. In this instance, however, iodisation was limited to the drinking water. Aerial disinfection with iodine vapour was omitted. Again the incidence of infection began to decline almost immediately and by the end of six or seven weeks the number of new cases had fallen to four or five weekly.

FARM 2 (*Sussex*).—This was a rearing farm consisting of 4,000-5,000 birds from one day to eight weeks old. The outbreak of coryza calling for treatment was of three months' standing. Exactly the same régime was adopted as in the initial trial on Farm 1, iodine disinfection being applied to both water and air.

Result.—The incidence of cases fell almost immediately after the iodine treatment was started. By the end of seven weeks the infection had completely

XUM

disappeared and the owner considered he never had better-looking birds on his farm.

FARM 3 (*Channel Islands*).—On this farm the same successful story unfolded. Between 4,000 and 5,000 severely affected chicks, aged from one day to twelve weeks, were treated with Lugol's solution in the drinking water and aerial disinfection of their premises.

Result.—During eight weeks of the iodine treatment the infection gradually subsided, only a few mild and unimportant cases remaining.

FARM 4 (*Oxfordshire*).—In contrast to Farms 1, 2 and 3, all of which were run on the intensive system, this was a holding of 350 pullets and laying hens kept on semi-intensive lines. The coryza infection was exceedingly virulent. Here, treatment was of necessity limited to the addition of Lugol's solution to the drinking water. Since the birds ranged out-of-doors, aerial disinfection was, of course, impossible.

Result.—After seven days on iodised water, the birds showed a marked and sustained improvement.

FARM 5 (*Wiltshire*).—Like No. 4, this farm of 800 birds of all ages did not lend itself to aerial disinfection. Treatment therefore consisted in iodising the drinking water only.

Result.—Marked improvement was seen within seven days of starting the treatment. In one pen of 65 badly affected birds, 58 had completely recovered.

In view of the satisfactory results on Farms 4 and 5, and also in the second phase of the trial on Farm 1, in none of which did air iodisation form part of the régime, it would appear that aerial disinfection in addition to the iodised water treatment may be unnecessary. Further experiments are in progress to decide this.

Summary

Severe and persistent outbreaks of fowl coryza on five large poultry farms, involving 25,000 birds in all, were treated with rapid and marked success by iodising the birds' drinking water to a concentration of one part of "free" iodine in 20,000 parts of water (achieved by adding one teaspoonful of Lugol's solution to every gallon of water) and by disinfecting the air of batteries and coolers by means of iodine vapour. Indications that iodised water alone is sufficient to effect cure are being further investigated.

Acknowledgments are due to the staff of the Poultry Department of the Ministry's Veterinary Laboratory, Weybridge, for their co-operation in this work.

REFERENCES

De Blieck, L. (1932): *Vet. J.*, *88*: 9.
Nelson, J. B. (1932): Quoted in "Diseases of Poultry," by H. E. Biester and L. Devries. Iowa: *College Press*, 1944.
Schalm, O., and Beach, J. R. (1934): *Science*, *79*: 416-417.
Delaplane, J. P., Erwin, L. E., and Stuart, H. O. (1934): *R.I. Agr. Expt. Sta. Bull.*, 244: 12 pp.
Delaplane, J P., and Stuart, H. O. (1936): *J. Agr. Res.*, *52*: 377-383.
Nelson, J. B. (1938): *J. Exp. Med.*, *67*: 847.
Delaplane, J. P., and Stuart, H. O. (1941): *J. Amer. Vet. Med. Assoc.*, *99*: 41-42.
Delaplane, J. P. (1943): R.I. *Agr. Exp. Sta. Bull.*, 288: 33 pp.
Renshaw, A. (1943): *Lancet*, *ii*, 237-238.
Beach, J. R. (1944): Quoted in "Diseases of Foultry," by H. E. Biester and L. Devries. Iowa: *College Press*, 1944.
Raymond, W. F. (1946): *J. Hyg.*, *44*: 359-361.

NATURAL AND EXPERIMENTAL CASES OF POISONING OF CALVES BY FLAKING LEAD PAINT*

By E. G. WHITE and E. COTCHIN
Research Institute in Animal Pathology, Royal Veterinary College.

OF the various possible sources of lead in cases of lead poisoning in calves, fresh paint appears to be the best known. Recent experience, however, has indicated that another dangerous and often unsuspected source is old flaking paint. Since 1939, twenty-seven cases of probable or proved lead poisoning have been encountered by us in calves varying from two to forty weeks in age. In twenty-one of these cases there was proved contact with lead paint, generally in the form of old flaking paint on doors, mangers, and partitions of calf pens. This paint was sometimes difficult to see under accumulations of whitewash or dung. In some cases the calves were housed in pens built partly or entirely of old painted doors bought at saleyards, and paint scraped from one of these doors was available for experimental use.

The details of the natural cases in which lead poisoning was confirmed or strongly suspected are given in Table I. In eleven of the twenty-one calves

TABLE I
Natural Cases of Lead Paint Poisoning in Calves.

Calf No.	Age in weeks	Contact with Paint	Paint flakes in Stomach	Pb content (p.p.m.) Liver	Kidney
Found dead:					
1	3	+	+	40.0	—
2	3	+	+	13.3	33
3	20	+	+	—	—
4	24		+	—	—
5	24		+	—	—
6	2	+		—	—
7	24	+		—	300
8	3	+		—	—
Died after suspicious symptoms:					
9	5	+	+	25.0	50
10	40	+	+	50.0	15†
11	40	+	+	—	—
12	?	+	+	16.0	—
13	3	+	+	—	—
14	8	+	+	—	—
15	20	+	+	—	—
16	?	+	+	—	—
17	16		+	—	—
18	24		+	—	—
19	?		+	—	—
20	5	+		160.0	—
21	20	+		—	4
22	24	+		20.0	—
23	?	+		40.0	—
24	12	+		—	—
25	16	+		—	—
26	16	+		—	—
27	10			20.0	0.5†

p.p.m. = parts per million. ? = not known. + = present. † See footnote, p. 91.

* Part of the material in this article was incorporated in a thesis submitted by one of the authors (E.G.W.) for the F.R.C.V.S. diploma.

XUM

known to have been exposed to lead paint—which often showed signs of having been licked or chewed by the calves—flakes of paint, blackened on the outside, could be demonstrated in the stomachs. Such flakes were also found in five of the six calves not definitely known to have been exposed to paint at the time of illness or death. Thus at least sixteen of the twenty-seven calves had ingested lead paint. As one of the cases occurred in a calf which had been removed from a calf-pen with painted doors and walls three weeks before it developed fatal symptoms, it is necessary to be cautious in concluding from the mere absence of paint from the pen in which the calf is seen ill that paint poisoning is out of the question.

The blackened, heavy, friable flakes of paint could be found by placing the stomach contents in a white tray and examining under a good light, or, more easily, by placing some of the contents in a deep tray or other container: this was then filled with water, and the fluid immediately poured off, carrying with it the lighter material; this was then repeated several times, till heavy material only remained in the tray, including the paint flakes. A few of these flakes were picked out and tested for lead. They were placed in a boiling-tube, and a little concentrated nitric acid was added: after boiling, the mixture was filtered into an evaporating dish, and then evaporated to dryness over a water-bath. The residue, containing lead nitrate, was dissolved in a little distilled water, and a small crystal of potassium iodide was added: a yellow precipitate of lead iodide was formed, which was soluble in excess of potassium iodide and in hot water, re-crystallising from the latter on cooling in the form of shining golden plates.

From Table I it will be seen that eight calves were found dead without symptoms having been previously observed. Three of these (1, 2, 3) were known to have been in contact with lead paint and also showed flakes of paint in their stomachs. Two others (4, 5) showed paint flakes in their stomachs, and the remaining three (6, 7, 8) were known to have been exposed to paint. Chemical analysis of material from three of these calves (1, 2, 7) showed the following amounts of lead to be present: *Calf 1*—liver, 40 parts per million (p.p.m.). *Calf 2*—liver, 13.3 p.p.m.; kidney, 33 p.p.m. *Calf 7*—kidney, 300 p.p.m.

Nineteen of the twenty-seven calves showed symptoms suggestive of lead poisoning before death. These were generally: nervous derangement, as shown by convulsions, blindness, bellowing, with great excitement or even frenzy or apparent terror, attempts to climb walls or gates, etc., pressing the head, which was held low, against the wall or manger. Salivation was often observed, and sometimes lachrymation. In one or two cases high temperatures were recorded (107 deg. F. to 110 deg. F.). There was sometimes severe sweating. In less acute cases the calves were dull and appeared dejected, and would grind their teeth and show other signs of colic; the appetite was poor, and the unthriftiness might last for a long time and necessitate slaughter, or the calf would develop acute symptoms and die. These chronic cases often presented a difficult diagnostic problem unless the presence of lead paint on the premises gave a clue to their probable nature.

Of the nineteen calves which had shown suspicious symptoms prior to death, eight (9-16) had paint flakes in their stomachs and were known to have been in

contact with paint. Three others (17, 18, 19) had paint flakes in their stomachs, and seven of the remaining eight had been in contact with flaking old lead paint. Chemical analysis of material from eight of these calves (9, 10, 12, 20, 21, 22, 23, 27) showed the following amounts of lead to be present: *Calf 9*—liver, 25 p.p.m.; kidney, 50 p.p.m. *Calf 10*—liver, 50 p.p.m.; kidney, 15 p.p.m. *Calf 12*—liver, 16 p.p.m. *Calf 20*—liver, 160 p.p.m. *Calf 21*—liver, 0; kidney, 4 p.p.m. *Calf 22*—liver, 20 p.p.m. *Calf 23*—liver, 40 p.p.m. *Calf 27*—liver, 20 p.p.m.; kidney, 0.5 p.p.m.

In some of these cases a tentative diagnosis had been made of a foreign body such as a hair-ball or mass of binder twine in the fourth stomach, but it is suggested that any such diagnosis should probably be made with reserve if the slightest risk of lead poisoning is present.

Post-mortem findings in these natural cases were rather variable, and were sometimes negative. There was often excess fluid in the body cavities, and petechial hæmorrhages were often seen on the coronary fat, in the thymus, and beneath the kidney capsule. The lungs were often œdematous. The blood was found to be clotted in the great vessels, and there were sometimes signs of congestion of the mucosa of the abomasum and intestines, without, however, a definite gastro-enteritis.

Experimental Studies

The objection was often raised, when a diagnosis of lead poisoning had been suggested as a cause of death of calves, that other calves had been brought up in the same or similar conditions of exposure to lead without any sign of trouble. Still, amongst our cases were calves from premises where, due to failure to appreciate the potential danger of paint to calves, losses of similar type had occurred year after year, but had ceased when the paint was removed. Further, while it was generally admitted that calves might be and were poisoned by paint, it was suggested that the small amounts of paint that could have been ingested by some of the calves were below what might reasonably be thought to be a toxic amount. A still further possibility raised was that some substance in the paint other than lead was responsible for the poisoning. To obtain information on these points, experiments were carried out in 1943 and on an extended scale in 1945.

1943 Experiments

Three calves were used—S.1, S.2, and S.3.

Calf S.1

An Ayrshire calf was bought at the age of seven days from premises where access to lead paint, flaking or otherwise, was impossible, put in a loose-box with unpainted whitewashed walls, and kept for four days until it had settled down in the new surroundings and was taking calf-gruel and milk satisfactorily from a bucket. On the fifth day it was given a single oral dose of 10 g. of lead paint (paint A, 22 per cent. Pb) which had been scraped off an area of about one square foot of a painted door that had formed part of a calf-pen where previous losses

from lead poisoning had occurred. The scrapings were broken up finely, and tipped into the calf's mouth and washed down with a little warm water. This calf remained normal until the sixth day after dosing, when it was salivating a little and seemed rather dull. The next day it was heard bellowing, and found in a fit, struggling, walking in circles, and staggering about, with eyes rolling. The calf went down ten minutes after being first seen, and remained in convulsions, sweating and salivating profusely, until it died quietly an hour later. Five minutes before it died, and at the time of death, the rectal temperature was 112 deg. F.

At *post-mortem* examination, sub-epicardial petechiæ were found, especially along the course of the coronary vessels, and there were sub-endocardial ecchymoses in all the heart chambers, especially on the left side. The brain was congested, œdematous, and very soft. *Rigor mortis* was very pronounced within ten minutes after death, probably due to the previous intense muscular activity. Blackened paint flakes were found in the stomach. Chemical analysis showed the stomach contents to contain 60 p.p.m. of lead, the liver 13 p.p.m., and the kidneys 14.6 p.p.m.

It appeared that a single dose of 10 g. of the paint, containing 2.2 g. of Pb, could kill a 12-days-old calf in seven days. It was decided to see if the same amount given as a series of small doses would have the same effect.

Calf S.2

A second Ayrshire calf was obtained when four days old from the same source as calf S.1. A week after purchase, when the calf was making normal progress on calf-gruel and milk, the first of twenty daily doses of 0.5 g. of paint A was given. No symptoms were observed throughout the twenty days of paint feeding, except for the passage occasionally of yellowish clay-coloured fæces. Ten days after the last 0.5 g. dose, as the calf still appeared normal, it was given 10 g. of paint A as a single dose. It remained normal for the next sixteen days, and it was then slaughtered. Paint flakes were found *post-mortem* in the stomach contents. The Pb content of the liver was 9 p.p.m., and of the kidneys 16 p.p.m. It is not possible to say, of course, whether this calf would have died of lead poisoning if it had been kept longer.

In order to see whether a soluble lead salt was toxic in doses containing amounts of lead roughly corresponding to the lead in paint A, a third calf was given doses of lead acetate.

Calf S.3

A third Ayrshire calf, eight days old, was given 0.5 g. of lead acetate ($[CH_3COO]_2.Pb.3H_2O$) (=54.6 per cent. Pb). This dose, containing 0.27 g. Pb, and corresponding to about 1.25 g. of paint A, had no effect. Six days later the calf was given 1.0 g. of lead acetate. The seventh day after this dose it staggered a little, but seemed normal the following day. Eight days after the dose of 1.0 g. it was given a dose of 2.0 g. of lead acetate, corresponding to about 5 g. of paint A. The calf became very dull and was very weak on its legs for the six succeeding

days, and on the fourth day it showed a temporary blindness. Eight days after the 2.0 g. dose, a further dose of 4.0 g., corresponding to 10 g. of paint A, was given. The calf was now in a very weak condition, and died during the night of the third-fourth day following this dose.

At *post-mortem* examination, slight excess of fluid was found in the pericardial sac, the lungs and liver were congested, the mucosal folds of the abomasum were swollen and œdematous, and the brain seemed soft; no hæmorrhages were found in the heart, thymus, or kidneys. The lead content of the liver was 36 p.p.m., and of the kidneys 34 p.p.m.

TABLE II

Toxicity of Lead Paint and of Lead Acetate for Calves when given per os.
(1943 experiments)

Calf No.	Age at first dose (days)	Material used	Dosage (g.)	Result	Pb content, p.p.m. Liver	Kidney
S.1	12	Paint A	*10* (2.2)	Died 7th day.	13	14.6
S.2	11	Paint A	1. 20* *0.5* (0.11)	Normal for 20 days of dosing and further 10 days.		
			2. 10 days later, *10* (2.2)	Normal for further 16 days. Destroyed.	9	16.0
S.3	8	Lead acetate	1. *0.5* (0.27)			
			2. 6 days later, *1.0* (0.55)	Staggered 7th day after dose.		
			3. 8 days later, *2.0* (1.1)	Dull and weak next day and for 6 days.		
			4. 8 days later, *4.0* (2.2)	Died in night of 3rd-4th day.	36	34.0

Figure in brackets after dose (italic figures) indicates amount of Pb in dose in g. Paint A contains 22 per cent. Pb. Lead acetate contains 54.6 per cent. Pb. * Daily doses of. p.p.m. = parts per million.

The results of the 1943 experiments are summarised in Table II. No very definite conclusions could be drawn from the somewhat conflicting results of these experiments, but they were briefly mentioned in a note in *Agriculture* (White and Cotchin, 1944) which directed attention to the danger of old flaking paint to calves. The experiments were continued on a larger scale in 1945, when the toxic effects of lead paint and of lead carbonate were studied.

1945 Experiments

In these experiments, seven calves were dosed with lead paint, the results being summarised in Table III. Two calves were dosed with lead carbonate, the results being summarised in Table IV. One calf was kept as control.

(A) Experiments with Lead Paint

Three samples of lead paint were used in the experiments. Paint A was the white flaking paint that had been used in the 1943 experiments, and contained 22 per cent. Pb. Paint B was white flaking paint obtained from the woodwork of a greenhouse which had not been repainted for many years, and contained 67

TABLE III

Toxicity of Lead Paint for Calves, given per os.
(1945 experiments)

Calf No.	Age (weeks)	Paint used	Dosage (g.)	Result	Pb content, p.p.m. Liver	Kidney
S.13	1	B	*10* (6.7)	Died 9th day.	182.0	149.0†
S.12	1	B	12* *2* (1.34)	Died 7 days a.l.d.	34.0	180.0
S.9	10	A	10* *5* (1.1)	Poor vision 6 days a.l.d.		
		A	10 days later, 10* *5* (1.1)	Normal during dosage and 4 succeeding days.		
		B	4 days later, 10* *10* (6.7)	Two fits 8th day of dosage. Died 20 days a.l.d.	41.0	140.0
S.10	10	A	10* *1* (0.22)			
		A	10 days later, 10* *1* (0.22)			
		B	4 days later, *100* (67)	Ill 5 days a.l.d. Normal 24 days a.l.d. Destroyed.	10.6	34.4
S.11	13	B	10* *10* (6.7)	Ill 2 days a.l.d. Killed *in extremis* 7 days a.l.d.	64.5	48.4†
S.6	24	A	10* *1* (0.22)			
		A	10 days later, *10* (2.2)	Normal 14 days a.l.d.	3.2	1.8†
S.4	28	A	10* *5* (1.1)			
		A	10 days later, *50* (11)			
		C	14 days later, 10* *12* (2.04)	Died 1 day a.l.d.	9.5	11.0

Figure in brackets after dose (italic figures) indicates amount of Pb in dose in g. Paint A contains 22 per cent. Pb, Paint B 67 per cent., Paint C 17 per cent. * Daily doses of. p.p.m. = parts per million. a.l.d. = after last dose. † See footnote, p. 91.

per cent. Pb. Paint C consisted of green paint flaking off a corrugated iron building, and contained 17 per cent. Pb. The details of the experiments on the calves are as follows, being given in the order of the age of the calves.

Calf S.13

This was a seven-days-old calf, twin to the next, S.12. It was given a single dose of 10 g. of paint B. The animal was normal for the next eight days. On the morning of the ninth day following dosing it was still normal, but in the afternoon it was grinding its teeth at 2.30 p.m., and at 3 p.m. it was heard bellowing. It then broke through the wooden paling fence of the pen, and rushed about madly, dashing against the fence and wall of the shed. When it was shut up once again, it pushed very hard against the fence or any other obstruction, the head being held low, and the greatest difficulty was experienced in trying to pull it away, all the muscles of the body seeming to be employed to maintain its position. After about ten minutes the calf went down on its brisket, still pushing against the wall. It did not seem to be blind. There were violent spasms of the diaphragm, and contractions of voluntary muscles. The rectal temperature was 106 deg. F. The animal remained like this for a further fifteen minutes, gradually became weaker, and died quietly at 3.30 p.m., the rectal temperature still being 106 deg. F. The calf had been in poor condition during the three or four days before death, and

the carcass weight was only one kg. more than when dosing began nine days previously.

Post-mortem examination showed paint flakes in the stomachs, and a slight excess of pericardial fluid, but nothing else of importance was noted. Analysis for lead showed 182 p.p.m. in the liver, 149 p.p.m. in the kidneys, and 2 p.p.m. in the brain.

Calf S.12

This was a seven-days-old calf, twin to S.13. It was given twelve daily doses of 2 g. of paint B. The animal remained normal during the dosing period and for five days afterwards. On the sixth day the calf was dull, very thirsty, and passed a large firm stool. It bellowed at intervals during the day. On the seventh day, at 6.30 a.m., the calf was heard bellowing and seen rushing madly about, banging into the walls of its shed. It died thirty minutes later in a typical "fit." During the nineteen days since it was first dosed, the calf had gained 9 kg. in weight, and was in excellent condition.

At *post-mortem* examination, the trachea was found to contain bloodstained froth, there was congestion and some petechiation of the lungs, and many petechiæ were present on the heart and under the endocardium and in the thymus. The kidneys showed patchy congestion, and the cortex was soft and friable. The stomachs contained black flakes. There seemed to be an excess of cerebrospinal fluid. The liver contained 34 p.p.m. of lead, the kidneys 180 p.p.m. (medulla 13.3, cortex 216), and the brain 1 p.p.m.

The next three calves were ten weeks old when received, and were in excellent condition. It was known that there had been no exposure to lead paint since birth. They had been fed entirely on milk, but were rapidly weaned on arrival and transferred to solid food.

Calf S.9

This calf received ten daily doses of 5 g. of paint A. Six days after the last dose vision seemed impaired: when lying in the loose-box the calf appeared to have some difficulty in distinguishing a person at the door of the box, and, although it did not stumble into objects outside the box, it found some difficulty in negotiating the shallow step from the shed into the yard. Four days later vision seemed normal again. Ten days after the last dose of 5 g. the animal was started on another course of ten daily doses of 5 g. of paint A. No symptoms appeared during the period of administration or during the four succeeding days, and on the fourth day it was started on a course of ten daily doses of 10 g., this time of paint B. Eight days after the first of these doses the calf was seen to jump suddenly into the air, rush into the fence, jump up the wall of the shed almost to the roof, fall, and get up again five seconds later. It then pushed hard with its head and neck against the fence. A minute later the animal was pacing round the pen, its breathing was laboured and rapid, and it was salivating and champing its jaws. The rectal temperature was now 104.5 deg. F. A second "fit" was observed forty-five minutes later, lasting two minutes. For several days after

XUM

this the calf stood with its head held low, or pushed against the wall of the shed or the fence, and more than once it collapsed. It refused food completely and very rapidly lost condition. Vision was again impaired, muscular weakness was marked, the ears were cold, and there was poor muscular co-ordination, the animal tending to drag its hind legs and to allow its hind quarters to sway from side to side. It stumbled over its bucket and trough, but was not actually blind. It survived in this weak condition for some time, and even appeared to improve slightly, but it was found dead twenty days after receiving its last dose of paint. Six days before death it showed a curious gait when walking—the fore-feet were raised almost to the level of the chin; this peculiar gait had disappeared the next day. Throughout the period it refused food; it seemed anxious to eat, but was unable to chew or swallow when food was placed in its mouth.

Post-mortem examination showed the animal to be in very poor condition, the body fat being gelatinous and present only in small amount. The abomasum contained many black flakes giving a positive test for lead. Analysis showed 41 p.p.m. of lead in the liver, 140 p.p.m. in the kidneys, and 1 p.p.m. in the brain.

Calf S.10

This calf was given ten daily doses of 1 g. of paint A. There were no symptoms, and ten days after the last dose the same dosage was repeated. Four days after the last dose of this series the animal was normal and in excellent condition. It was then given a single dose of 100 g. of paint B. Five days later it was found semi-comatose, lying on its brisket and breathing very rapidly, the rectal temperature being 108 deg. F.: it had appeared normal two hours earlier. Next morning the calf was standing in a corner of its shed with its head held down, drooling thick viscid saliva. It refused food: the head was continually being held down to the food in the trough, but none was eaten. The ears were cold. In the shade inside the shed the animal appeared to see people and objects only with difficulty. Four days later there was a definite improvement and the animal rapidly gained weight so that when killed twenty-four days after the 100 g. dose it was in excellent bodily condition and appeared to be quite normal.

No abnormality was found at autopsy, except for the presence of black flakes in the stomach contents. Analysis showed 10.6 p.p.m. of lead in the liver, 34.4 p.p.m. in the kidneys, and 4.3 p.p.m. in the brain. The figure for the concentration of Pb in the brain is unexpectedly high, and is open to doubt; it is suspected that contamination of the material analysed may have occurred.

Calf S.11

Three weeks after being received at the age of ten weeks, this calf was given ten daily doses of 10 g. of paint B. Two days after the last dose the animal refused food, and its condition steadily worsened until, seven days after the last dose, it was extremely emaciated, so weak that it could hardly stand, and was almost comatose. Vision had been impaired throughout the preceding seven days. The animal was killed *in extremis*.

Post-mortem examination showed an emaciated carcass, with gelatinous

XUM

œdema in the fat depôts, and excess cerebrospinal fluid which appeared to be under considerable pressure. Paint flakes were found in the stomach contents. Analysis showed 64.5 p.p.m. of lead in the liver, 48.4 p.p.m. in the kidneys, and less than 1 p.p.m. in the brain.

Five other calves (S.4, S.5, S.6, S.7, S.8) used in the experiments were bought from a farmer. There was no evidence that any of these five had been exposed to lead paint.

Calf S.6

This was a six-months-old Guernsey calf. It was given ten daily doses of 1 g. of paint A. The calf remained normal for ten days after the last dose, and it was then given a single dose of 10 g. of paint A. It was normal for a further fourteen days, and was then killed. No pathological changes were seen at *post-mortem* examination. Analysis showed 3.2 p.p.m. of lead in the liver, and 1.8 p.p.m. in the kidneys.

Calf S.4

This was a seven-months-old Friesian calf. It was given ten daily doses of 5 g. of paint A. No symptoms were observed during the ten days of dosage, or during the ten succeeding days. The animal was then given a single dose of 50 g. of paint A, but remained normal for a further fourteen days. It was then given ten daily doses of 12 g. of paint C. The day following the last dose of this series it lost interest in its food, champed its jaws, and drooled saliva profusely. It walked aimlessly around the pen, holding its head low. At 7.20 p.m. on the same day the calf was heard kicking violently, and was found in a fit in its shed. It was lying on its side, and frothing at the mouth, with the tongue clenched between its teeth and its legs jerking. The rectal temperature was 107 deg. F. The animal died at 7.35 p.m., and at the time of death the rectal temperature was 111 deg. F.

Post-mortem examination, made the next morning, showed the animal to be tympanitic with the anus protruding. The serous cavities contained a small amount of bloodstained fluid. The kidneys were soft, but no hæmorrhages were seen in them. There were petechiæ under the epicardium, in the thymus, and in the mediastinal fat. The liver contained two abscesses, each the size of a walnut, filled with creamy pus containing *C. pyogenes*. The brain appeared normal macroscopically. In the abomasum there were many black flakes, and a few flakes were seen in the rumen and reticulum. Some of the flakes in the stomach were still the bright green colour of paint C, but most of them were blackened. The intestines were normal, and the rectum contained firm clay-like fæces. The musculature of this calf was paler than normal for its age. The animal had gained about 38 kg. in weight in the six weeks' experimental period from its initial weight of 88 kg. Analysis showed 9.5 p.p.m. of lead in the liver, 11 p.p.m. in the kidneys, and less than 1 p.p.m. in the brain.

Calf S.8

This six-months-old black poll calf had been selected by lot from the group

XUM

S.4-S.8 as a control. It was kept for ten weeks and then slaughtered fourteen days after the last of the paint-fed calves in the group. It thrived well, and had shown no symptoms of illness, except that once it had been seen to jump suddenly into the air, yet autopsy showed lesions of tuberculosis to be present on the peritoneum, in the spleen, in the mesenteric, posterior mediastinal, retropharyngeal, suprasternal, and inferior cervical lymph nodes, and a single caseous lesion was found in the middle of the pons. No black flakes were found in the stomach contents, and analysis showed less than 1 p.p.m. of lead in the liver, kidneys and brain.

Summary of Experiments with Paint

In the 1943 and 1945 experiments with paint it was found that a single dose of 10 g. of paint A (=2.2 g. Pb) killed a twelve-days-old calf (S.1) in seven days, and a single dose of 10 g. of paint B (=6.7 g. Pb) killed a seven-days-old calf (S.13) in nine days. Ten g. of paint A given as twenty daily doses (=0.11 g. Pb daily), followed by a single dose of 10 g. of paint A (=2.2 g. Pb), did not, however, affect a calf (S.2) eleven days old at the beginning of dosing. Twelve daily doses of 2 g. of paint B (=1.34 g. Pb daily) killed a calf (S.12), seven days old when first dosed, seven days after the last dose.

Older calves appeared to be more resistant, but could still be killed by larger doses of paint. A total of 200 g. of paint (100 g. paint A=22 g. Pb, and 100 g. paint B=67 g. Pb) killed a calf (S.9) which was ten weeks old when first dosed. A total of 220 g. of paint (100 g. paint A=22 g. Pb, and 120 g. paint C=20.4 g. Pb) killed a calf (S.4) seven months old when first dosed. On the other hand, one calf (S.6), six months old when first dosed, received a total of 20 g. of paint A (=4.4 g. Pb) without apparent effect. One hundred g. of paint B (=67 g. Pb) made one calf (S.11), thirteen weeks old when first dosed, so ill that it was slaughtered *in extremis*, while 120 g. of paint (20 g. paint A=4.4 g. Pb, and 100 g. paint B=67 g. Pb) caused a temporary illness only in one calf (S.10), ten weeks old when first dosed.

(B) Experiments with Lead Carbonate

That the deaths of the calves given lead paint orally were due to the lead in the paint was considered likely as chemical analysis of the paints used showed that lead was the only potentially poisonous substance present in significant amounts. Further, typical symptoms and death were produced in two calves given lead carbonate by mouth (see Table IV.)

Calf S.5

This was a 5½-months-old roan Shorthorn calf. It was given ten daily doses of 1.25 g. of lead carbonate ($PbCO_3$) (=77.6 per cent. Pb). No symptoms were seen during the period of dosing or for the next fourteen days, and the calf was then given a single dose of 12.5 g. of lead carbonate. It remained normal for a further fourteen days, and was given a single dose of 25 g. of lead carbonate. It remained normal for a further ten days, and was given a single dose of 60 g. of

TABLE IV

Toxicity of Lead Carbonate for Calves when given per os.

(1945 experiments)

Calf No.	Age at first dose (months)	Dosage (g.)	Result	Pb content, p.p.m. Liver	Kidney
S.5	5½	1. 10* *1.25* (0.97) 2. 14 days later, *12.5* (9.7) 3. 14 days later, *25* (19.4) 4. 10 days later, *60* (46.5)	Became dull 2 days a.l.d. Died 7 days a.l.d.	36.5	36.8†
S.7	5½	1. 10* *0.25* (0.19) 2. 10 days later, *2.5* (1.9) 3. 14 days later, 10* *4* (3.1)	Died 3 days a.l.d.	14.0	8.0†

Figure in brackets after dose (italic figures) indicates amount of Pb in dose in g. Lead carbonate contains 77.6 per cent. Pb. * Daily doses of. p.p.m = parts per million. a.l.d. = after last dose. † See footnote, p. 91.

lead carbonate. Two days after this last dose it refused its food and appeared dull. The symptoms continued the next day, and the animal was holding its head down. On the third day after dosing the animal was salivating profusely, and it remained in this condition until the seventh day. At 11 a.m. it went into a "fit"—it fell down suddenly on its left side and kicked violently. Within ten seconds it rose on to its brisket, and was on its feet again within a minute. It now walked round the pen in an aimless circular direction. At 12 noon it bellowed suddenly, rolled its eyes and went down, struggling violently, appearing terrified as it went down. It rose again and stood with its head pressed hard against the fence, its legs wide apart. It was breathing rapidly, but by 12.10 p.m. it had partly recovered. It was found dead at 12.40 p.m., the rectal temperature then being 109 deg. F.

Post-mortem examination showed a few sub-epicardial petechiæ. The internal organs felt uncomfortably hot even to the gloved hand. The liver and kidneys were pale and friable, especially the renal cortex. Granular material formed of blackened aggregations of lead carbonate was found in the stomachs and intestines. There was some reddening of the abomasal folds, but no true gastritis. There seemed to be an excess of cerebrospinal fluid. Analysis showed 36.5 p.p.m. of lead in the liver, 36.8 p.p.m. in the kidneys, and 1.2 p.p.m. in the brain. This calf had received a total of 110 g. of lead carbonate (= 85.3 g. Pb).

Calf S.7

This was a 5½ months old Shorthorn calf. It was given ten daily doses of 0.25 g. of lead carbonate. Ten days later, the animal still being normal, it was given a single dose of 2.5 g. of lead carbonate. It remained normal for a further fourteen days, and it was then given ten daily doses of 4 g. of lead carbonate. No abnormality was seen until two days after the last dose, when the calf went off its food and appeared dull. The next morning it was still not eating, and saliva was dribbling from its mouth. At 5.20 p.m. of the same day it was found dead, lying on its side. There were signs that it had kicked violently before death. Saliva and froth were seen around the mouth, and there was a small amount of blood at the nose. The carcass was warm and in *rigor mortis*.

XUM

Post-mortem examination showed petechiæ under the epicardium and endocardium, and a pale blurred kidney cortex. A large amount of cerebrospinal fluid escaped when the meninges were opened at the occipito-atlantal space. The brain was very soft. Analysis showed 14 p.p.m. of lead in the liver, 8 p.p.m. in the kidneys, and less than 1 p.p.m. in the brain.

These experiments support the view that the toxicity of lead paint is due to the lead.

In Table 5, the results of the 1943 and 1945 experiments are grouped together, according to the age of the calves, to show the actual amounts of lead received by each animal.

TABLE V

Toxicity of Lead Paint or Lead Salts (1943 *and* 1945 *experiments*), *expressed as Pb, for calves of different ages, when given per os.*

Calf No.	Age when first dosed	Total amount of Pb given per os (g.)	Lead content, p.p.m. Liver	Kidney
Died:				
S.13	7 days	6.70	182.0	149.0†
S.12	7 days	16.08	34.0	180.0
S.3	8 days	4.12	36.0	34.0
S.1	12 days	2.20	13.0	14.6
S.9	10 weeks	89.00	41.0	140.0
S.11*	13 weeks	67.00	64.5	48.4†
S.7	5½ months	34.80	14.0	8.0†
S.5	5½ months	85.30	36.5	36.8†
S.4	7 months	42.40	9.5	11.0
Survived after typical symptoms:				
S.10	10 weeks	71.40	10.6	34.4
Remained normal:				
S.2	11 days	4.40	9.0	16.0
S.6	6 months	4.40	3.2	1.8†

* S.11 was killed *in extremis*. † See footnote, p. 91. p.p.m. = parts per million.

Discussion

This experimental evidence seems sufficient to warrant the conclusion that flaking paint can kill calves experimentally and can produce symptoms, lesions, and levels of Pb in the tissues such as occur in natural cases of poisoning by flaking paint. Since approximately similar amounts of lead in the form of lead carbonate have the same effect, and since the paints used contained no other constituent likely to be dangerous, it is concluded that the toxicity of flaking paint is due to its lead content.

The symptoms of lead poisoning when expressed in the typical nervous form are sufficiently characteristic to suggest the diagnosis, particularly if frenzy and terror are manifested. Difficulty arises in those cases in which the calf is merely found dead, or where the main symptom is failure to thrive. In difficult cases, the post-mortem findings may be suggestive, and the presence of flakes of paint in the stomach will point to the probable diagnosis. A chemical analysis will be necessary if a definite diagnosis is required, but meanwhile other calves at risk can be removed from the suspected source of lead (which may be difficult to find), and possibly given magnesium sulphate, which causes the formation of lead sulphate and may also help elimination of lead flakes by acting as a purgative.

The acute nervous symptoms shown by cattle, especially calves, poisoned

by lead, recall those seen particularly in children and under circumstances of unusually heavy exposure in adult humans. The mortality in lead poisoning in calves showing acute nervous symptoms is very high—Udall (1939) says he has never seen such a case recover—but calves in contact with some of the cases mentioned in Table I had shown nervous symptoms, including "fits" and blindness, and in some cases had recovered. Calf S.10 in our experimental series had shown some nervous involvement, but had recovered. Despite the common occurrence of symptoms apparently originating in the C.N.S., very little lead appeared to be present in the brain; however, it is possible that the moist œdematous condition of the brain and the apparently increased cerebrospinal fluid pressure were related to the symptoms. The high temperatures encountered in some of the natural and experimental cases may have been due in part to the excessive muscular activity often noted, but they may have been related to brain involvement or some direct metabolic effect of lead; whatever their origin, it is important that a diagnosis of septicæmia as opposed to lead poisoning should not be thought more probable simply because the calf has a high temperature.

Post-mortem lesions that have been almost constant in the natural and experimental cases of lead poisoning have been petechial hæmorrhages in the endocardium and epicardium, and, particularly, in the thymus. There have also often been degenerative changes in the kidneys, indicated by a blurring of the cortical pattern. No true gastro-enteritis has been seen in our natural or experimental cases. Histologically, the kidneys showed degeneration of the epithelium of the proximal convoluted tubules. In material fixed in Regaud's fluid (formalin—potassium bichromate) from some cases, both natural and experimental, yellow structures were seen within the nuclei of these epithelial cells, and where the nuclei had undergone dissolution their site was marked by yellow particles within the necrotic cells. It was thought likely that these structures were lead chromate; in one or two animals the intranuclear inclusions were seen as almost colourless masses in formalin-fixed material, and it is possible that they represent intranuclear accumulations of Pb, and that their yellow colour in Regaud-fixed material is due to the formation of lead chromate. Intranuclear bodies have been described by Theobald Smith (1930) in the kidneys of calves which had received serum instead of colostrum, and they have been seen in the kidneys of children poisoned by lead, and also in the kidneys of rats fed lead acetate (Dalldorf and Williams, 1945). A few similar bodies were seen in some sections of liver from our calves.

Material taken for chemical analysis after death from cases of suspected lead poisoning in calves should include liver and kidney, but the examination of stomach contents or of brain does not appear to be essential: in the case of the stomach contents, no final significance could be attached to either a positive or a negative result, and in the case of the brain, the lead concentration is very low even in definite cases of poisoning. In the natural cases of lead poisoning in which a chemical analysis of the liver was made, values for Pb ranging from 0 to 160 p.p.m. were obtained. The diagnosis in the one case in which no lead was found was made on a history of typical symptoms and of proved contact

XUM

with paint, and is of course open to some doubt, but Udall (1939) records a similar experience of a negative chemical report after a positive clinical diagnosis.

In calves dying, or killed *in extremis*, after dosing with lead paint, liver values of Pb ranging from 9.5 to 182 p.p.m. were found. The two calves that remained normal after dosing with lead paint (S.2, S.6) had liver Pb values of 9 and 3.2 p.p.m. respectively, while the calf that showed symptoms but recovered after dosing with lead paint (S.10) had a liver Pb content of 10.6 p.p.m. The two calves which died after dosing with lead carbonate (S.5, S.7) had liver Pb values of 36.5 and 14 p.p.m. respectively, and the calf dying after dosing with lead acetate (S.3) had a liver Pb value of 36 p.p.m. The lead content of the liver of the control calf was less than 1 p.p.m. These values are of the same order as some mentioned in the literature. For example, Shrewsbury and others (1945) found Pb values ranging from 3.7 to 106.8 p.p.m. in the livers of eight calves poisoned as a result of chewing a fence painted with lead paint. In the livers of five calves experimentally poisoned with lead carbonate (four animals) or lead acetate (one animal) they found 56 to 514 p.p.m. of lead. Fenstermacher and others (1946), in twenty natural cases of lead poisoning, found liver values for lead ranging from 0 to 120 p.p.m. These authors consider that liver values for lead of 3 p.p.m. may be of no significance, 5 p.p.m. being suspicious, and 10 p.p.m. or more being a positive indication of lead poisoning.

In those of our natural cases in which the kidneys were submitted to analysis,† values ranging from 0.5 to 300 p.p.m. were recorded. In the experimental cases, calves dying or being killed *in extremis* after dosing with lead paint gave kidney Pb values ranging from 11 to 180 p.p.m. The two calves that remained normal after dosing with lead paint had kidney Pb values of 16 and 1.8 p.p.m. respectively, while the calf that showed symptoms but recovered had a kidney Pb value of 34.4 p.p.m. The two calves which died after dosing with lead carbonate had kidney Pb values of 36.8 and 8 p.p.m. respectively, and the calf which died after dosing with lead acetate had a kidney Pb value of 34 p.p.m. There was less than 1 p.p.m. of Pb in the kidney of the control calf. In calf S.12, most of the lead was contained in the cortex (216 p.p.m.) as opposed to the medulla (13.3 p.p.m.) of the kidney.

The interpretation of analytical findings for the lead content of liver and kidneys would be considerably facilitated if more information was available of the amount of lead that may occur in the liver and kidneys of normal animals exposed to normal risks of ingestion of lead in food and water, and in animals exposed to the risk of lead paint poisoning, but not developing signs of poisoning. In our control calf, the liver and kidneys contained less than 1 p.p.m. of lead. Shrewsbury and others (1945) give the normal content of liver of cows (five animals) as 0.0-0.06 p.p.m. (average 0.01 p.p.m.), and of calves 0.0-3.75 p.p.m. (average 0.93 p.p.m.). Fenstermacher and others (1946) found 0.5 and 8 p.p.m. in the liver of two "control" animals. In our experimental animals, the animals dosed with lead paint but remaining normal had liver values of 9 and 3.2 p.p.m., and kidney values of 16 and 1.8 p.p.m. respectively, while a calf recovering after showing symptoms had a liver value of 10.6 p.p.m. and a kidney value of

34.4 p.p.m. We are inclined to agree with Fenstermacher and others that levels of 10 p.p.m. or more of lead in the liver can be taken to indicate the probability of lead poisoning, but values around this figure should be interpreted in the light of the symptoms, post-mortem findings, and possibility of access to lead paint.

Considerable interest attaches to the problem of the smallest dose of lead that can kill a calf. Our experiments support the expected conclusions that young calves will be killed by an amount too small to kill an older calf, and that repeated small doses are less likely to be so dangerous as a single large dose. The smallest single dose that has killed a calf in our experiments is 10 g. of paint A, which contains 2.2 g. of Pb; this killed a twelve-day-old calf, and is a dose of lead of approximately 50 mg. per kg. Cantarow and Trumper (1944) state that, according to Flury, the smallest oral dose of lead capable of causing acute lead poisoning in man is 5 mg. per kg. body-weight. The smallest amount of lead considered to have been fatal to adult cattle is that mentioned by White and others (1943): they state that 18 of 20 cows which ingested, on a single day, silage contaminated with red oxide of lead estimated to furnish approximately 4.8 mg. of Pb per kg. body-weight, failed to survive, and the two survivors showed symptoms of acute lead poisoning. The evidence for the estimated lethal dose, about 1.65 g. of lead for each cow, was in this case, however, only indirect, and the figure given is to be accepted with reserve.

Udall (1939) mentions some experiments by Paige, who reported in 1908 that the feeding of 1 g. of arsenate of lead daily to a cow caused symptoms of poisoning after 26 days, and death in 40 days, when a total of 29 g. had been consumed. A second cow, weighing 240 kg., developed symptoms after 23 days when fed 0.5 g. of lead arsenate daily, and purging was violent after it had received a total of 16 g. A third cow was given 28.35 g. at a single dose in a gelatin capsule, and suffered from severe but non-fatal poisoning. A fourth animal was given 56.7 g. in a capsule and died after about 70 hours.

Miessner (1927) produced severe symptoms in a two-year-old bull with 85 g. of PbO. A calf weighing 80 kg. was given daily doses of 0.25 g. PbO per kg. body-weight until in three days a total of 60 g. had been given, and it died three days later. Using lead sulphide, a 1½-year-old bull weighing 250 kg. was given five daily doses of 20 g. without effect. A 45 kg. calf given five daily doses of 30 g. PbS (0.74 g. per kg. body-weight) died seven days later.

Haltenhoff (1932) gave not more than 60 g. of red lead, in the form of paint scrapings from a trough, to a five-weeks-old calf weighing 51 kg. Typical symptoms developed two days later and the animal was slaughtered. The liver was found to contain 15 p.p.m. of lead. In their experiments, Shrewsbury and others (1945) produced symptoms and death in five calves, varying from 19 to 68 days of age. Lead carbonate was given to four of the calves and lead acetate to the fifth over a period varying from six to 30 days in doses from 0.5 to 6.0 g. daily. The total amount of Pb fed before death occurred varied from 9 to 47 g. averaging 21.8 g. Some cattle fed lead-contaminated ground-nuts from stores damaged in air-raids at the rate of 1-2 lb. daily per head showed blindness and loss of control of the tongue and jaws, while others were highly nervous and

tended to wander aimlessly almost unceasingly. Each animal was estimated to be getting something under 1-2 g. of Pb daily (Williams, 1943). The amount of lead ingested by cows which showed symptoms of poisoning following the feeding of lead-contaminated salvaged soya bean meal was estimated to be about 3 g. daily (Watson and Adams, 1945).

There can be little doubt that the opinion, so widespread among veterinary observers, that bovine animals, and particularly calves, are extremely susceptible to lead poisoning is fully justified. Cases of poisoning due to old, flaking paint may have appeared to be more numerous during the war years as no re-painting could be carried out on the farms, and the paint already present gradually flaked off, but another possible factor—which, however, we did not investigate—may have been that calves were suffering from some deficiency that became pronounced during the war, so that they became more prone than usual to lick and chew at the walls and doors of their pens. It cannot be too strongly recommended that calves, in particular, should be kept away from contact with all objects coated with lead paint. If paint must be used, a lead-free paint is necessary. If the typical symptoms are seen in any calves, the search for lead paint should be a thorough one. In cases where calves are merely found dead, or fail to thrive, the possibility of lead poisoning being responsible is worth considering.

Summary

(1) Lead poisoning cases in calves appear to be quite commonly due to the ingestion of old, flaking paint from painted woodwork or from painted doors used in the construction of calf pens.

(2) The typical symptoms, lesions and tissue levels of lead were produced experimentally in calves fed on lead paint from premises where natural cases had occurred, and on other samples of lead paint.

(3) Similar symptoms, lesions and tissue levels of lead could be produced experimentally in calves by feeding them with lead carbonate, indicating that the toxic factor in lead paint is lead.

(4) An account is given of the symptoms, lesions, and liver and kidney levels of lead in the natural and experimental cases.

Acknowledgments

We are greatly indebted for the chemical analysis of paints A, B and C, and of material from calves S.4-S.13, to Dr. Ruth Allcroft; and for the analysis of material from calves S.1-S.3, to Dr. E. G. C. Clarke. A dithizone method was used throughout. Our thanks are also due to Mr. Kefford for the chemical analysis of material from the natural cases; he estimated lead as lead iodide.

REFERENCES

Cantarow, A., and Trumper, H. (1944): "Lead Poisoning." The Williams and Wilkins Company, Baltimore. P. 95.

Dalldorf, G., and Williams, W. R. (1945): *Science, 102,* 668-670.

Fenstermacher, R., Pomeroy, B. S., Roepke, M. H., and Boyd, W. L. (1946): *Jour. Amer. vet. med. Assn., 108,* 1-4.

Haltenhoff, R. (1932): *Arch. wiss. prakt. Tierheilk., 65,* 360-370.

Miessner, H. (1927): *Deutsch. tierärztl. Wschr., 35,* 297-301.

XUM

Shrewsbury, C. L., King, F. G., Barrick, E., Hoeper, J. A., and Doyle, L. P. (1945): *Jour. Anim. Sci., 4,* 20-23.
Smith, Th. (1930): *J. Exp. Med., 51,* 519-529.
Udall, D. H. (1939): "The Practice of Veterinary Medicine." Ithaca, New York. Pp. 635-640.
Watson, A. H., and Adams, A. J. (1945): *Vet. Rec., 57,* 161.
White, W. L., Clifford, P. A., and Calvery, H. O. (1943): *Jour. Amer. vet med. Assn., 102,* 292-293.
White, E. G., and Cotchin, E. (1944): *Agriculture, 51,* 85-86.
Williams, F. T. (1943): *Vet. Rec., 55,* 98.

† Dr. Ruth Allcroft informs us that in work (unpublished) at Weybridge on experimental lead poisoning in calves, the concentration of Pb has always been found to be greater in the kidney cortex than in the liver, and very much greater in the cortex than in the medulla of the kidney. That some of our calves appeared to show a lower concentration of Pb in the kidney than in the liver might in some cases have been due to the presence of an undue proportion of medulla in the portion of kidney analysed; for example, in the case of calves S.5, S.6, S.7, S.11 and S.13, the material was stored for a considerable time in the ice-chest before analysis, when autolytic changes made it impossible to distinguish clearly between cortex and medulla. Further, it is possible that from some undetected analytical error the relatively lower figures for the kidney Pb concentration in calves 10 and 27 from the series of natural cases might also be inaccurate.

THE INCIDENCE OF TUBERCLE BACILLI IN CAIRO MARKET MILK*

By AHMED ROUSHDY, M.V.Sc.(Cairo)
Lecturer in Hygiene, School of Veterinary Medicine, Fouad I University, Cairo, Egypt

Introduction

ATTENTION was drawn to milk as a means of conveying tuberculosis to the consumer as far back as 1869—that is, before the discovery of the tubercle bacillus by Koch in 1882, when Gerlach proved the infectiousness of milk from highly tuberculous animals through feeding and inoculation experiments. Besides the risk of transmission of infection to man, economic losses result from the decrease in the milk secretion of infected cows. Hence, in almost all civilised countries, measures for the sanitary control of the milk supply have been studied and enforced with progressively greater strictness.

No bacteriological research with the object of determining the incidence of tubercle infection, so far as we know, has been undertaken on the market milk of Cairo. Our aim has been, therefore, to obtain some light on the condition of this highly important and even indispensable foodstuff in respect of infection with tubercle bacilli.

Literature.—The presence of tubercle bacilli in the market milk of different countries was proved as early as 1893 by Montifusko in Naples, in 1894 by Friis in Copenhagen, in 1895 by Obermuller, in 1900 by Beck in Berlin, in 1895 by Zacharbko in St. Petersburg, in 1897 by Massone in Genoa, Buege in Halle, Royce and Delepine in Liverpool, and Klein in London, with results fluctuating between 0 and 100 per cent.

In 1907, Bouegge, in Schleswig-Holstein, proved the presence of tubercle

* Part of a Thesis accepted by the Fouad I University, Cairo, for the Degree of M.V.Sc. in 1944.

bacilli in 35 out of 258 bulk milk samples (13.5 per cent.), and in 32 out of 597 individual milk samples (5.2 per cent.). Thus, he found that the proportion of infected milk rose considerably when milk was bulked.

In 1907, Anderson found that the market milk of Washington, D.C., contained tubercle bacilli in 10.7 per cent. of milk samples. Later, Schroeder (1910) examined the milk in 26 dairies and found 7.7 per cent. of the milk samples contained tubercle bacilli, while still later Mohler (1911) showed that out of the 73 samples of milk which he examined, 3 per cent. only contained tubercle bacilli. The gradual decrease in the percentage of infected milk was attributed to the regulations enforced to pasteurise the market milk of Washington.

In 1911, Briscoe and McNeal compiled data from various countries, stating that out of 7,573 milk samples examined, tubercle bacilli were isolated from a total of 515 samples (6.8 per cent.). Moore (1911), in New York, examined 87 milk samples from a dairy herd and found two samples containing tubercle bacilli, and these were traced to two cows with tuberculous mastitis.

In 1927, Tonney, White and Danforth compiled data covering 16,700 samples of milk examined for the presence of tubercle bacilli in different countries, with 1,448 positive samples (8.66 per cent.).

In 1936, Prezpardo examined 200 samples of market milk in Madrid, among which 16 were positive (12.5 per cent.), mostly bovine.

In 1938, Legrand, Gernez and others demonstrated by guinea-pig inoculation that four out of 75 samples (5.3 per cent.) of milk delivered for human consumption direct from the farms in Northern France contained living tubercle bacilli. De Vine, B. (1938) reported that the Veterinary Department of the City of Birmingham, at the initial testing of herds, found that approximately 40 per cent. of adult cows react; and during the same period, the authorities had submitted to the guinea-pig inoculation test samples of bulk milk from farms supplying the city, and had found 7.5 per cent. to contain living tubercle bacilli.

The infectivity of the bovine tubercle bacilli for human beings had been proved by many research workers. In 1911, Park and Krumwiede, in New York, stated that the bovine tubercle was of little importance in adults, but caused a considerable percentage of child tuberculosis, and that 12.5 per cent. of deaths from tuberculosis in children were due to the bovine tubercle bacillus. Novick (1920) stated that Rosenau, having analysed 1,040 cases, including those studied by Park and Krumwiede, by the English and German Commissions and some isolated cases collected from the literature, came to the following figures: 16 years and over, out of 686 tuberculous cases, two were caused by the bovine type (1.3 per cent.); between 5 and 16 years, out of 132 cases, 33 were bovine (25 per cent.); and under 5 years, out of 120 cases, 59 were bovine (49 per cent.). The striking feature of these figures is the alarming percentage of bovine infection in children under 5 years of age (49 per cent.). He further stated that undoubtedly this high percentage was due to milk entering as the chief element in the diet of children and serving as the probable path of transmission of tuberculous disease to the young.

In 1923, at the National Milk Conference held in London, Griffith gave details in regard to 1,215 English and Scottish cases in which 935 (77 per cent.) were of human origin and 280 (23 per cent.) were of bovine origin. Jordan stated that 2,000 human deaths in England and Wales each year may be ascribed to bovine tuberculosis derived from cow's milk, and at least 4,000 fresh human cases infected with bovine tuberculosis possibly occur yearly. Cobbett gave 6.44 per cent. of the total deaths from tuberculosis as due to the bovine type.

In 1936, Griffith stated that out of 541 cases of tuberculosis of bones and joints, 18.7 per cent. of the cases were caused by the bovine bacillus. This percentage referred to patients of all ages, and if only children under 5 years were considered the percentage rose to 30 per cent., and under 10 years it was 25 per cent. In 1940, he found that out of 515 cases of human pulmonary tuberculosis in middle and south of Scotland, 484 were of human type and 31 of bovine type.

Experimental

Collection of Milk Samples.—Two hundred milk samples, collected in clean sterile bottles from shops and street salesmen in such order that they were evenly distributed among the different sections of Cairo, were examined. The samples were taken directly to the laboratory, then examined for the incidence of tubercle bacilli by the following three methods:—

(1) The microscopic method.
(2) The cultural method.
(3) The animal inoculation method.

Each sample was first of all examined to determine whether it was raw, boiled or mixed raw and boiled milk by Storch's test. The results are shown in Table I.

TABLE I.

	Raw	Mixed	Boiled
Out of 200 milk samples ...	76 (38%)	80 (40%)	44 (22%)

Methods

(1) *The microscopic method.*—The technique adopted was that recommended by Torrance (1927) and modified by Matthews (1931), and Maitland and Mary (1937). Ten c.c. of the well mixed sample was centrifuged at 2,500 r.p.m. for three minutes. The cream and supernatant fluid were poured off and two loopfuls from the sediment were spread evenly on a clean sterile slide in a fairly thick film. The smear was dried in air, fixed in the flame and stained with Ziehl-Neelsen's stain, using 3 per cent. HCL in 70 per cent. alcohol for decolorisation (Downham, 1931). The film was first examined under the low power for the detection of any cell grouping if present, and then under the oil-immersion lens for acid-fast bacilli.

(2) *The cultural method.*—The medium used was that recommended by Wahby (1932): 2 g. yeast extract, 2 g. peptone and 1 g. glucose dissolved in 100 c.c. distilled water and heated in streaming steam. To this mixture is added 10 g. potato flour suspended in 50 c.c. distilled water. The whole mixture is heated on a water bath until it gels, then cooled to 50° C., and eight fresh egg yolks

XUM

are added and mixed well with the original mixture, then strained through gauze; 5 c.c. of glycerine, 2.1 c.c. of normal KOH solution and 3 c.c. of 1 per cent. freshly prepared solution of brilliant green are added to each 100 c.c. medium. The finished medium has a pH of 7.1 to 7.2. The whole medium is then thoroughly mixed and tubed in sterile test tubes in slants and sterilised by fractional sterilisation at 80° C. for one hour on the first day and at 75° C. for one hour on two successive days. Before use, it was tested for sterility by incubation at 37° C., then the sterile tubes were kept in a dark, cool place.

Treatment of the milk sediment.—The sediment of a centrifuged 20 c.c. portion of the milk sample was mixed for 10 minutes with a normal solution of KOH with occasional stirring and then centrifuged for 5 minutes at a speed of 3,000 r.p.m. The supernatant fluid was poured off and 10 c.c. of 7 per cent. of concentrated HCL (2.45 actual HCL percentage) were added to the sediment and thoroughly mixed for 10 minutes, after which it was centrifuged again for 5 minutes. The supernatant fluid was poured off and the sediment was inoculated on two tubes. Accordingly, the small amount of acid in the sediment lowers the pH of the medium from 7.1-7.2 to 6.9-7, which is the suitable reaction for the growth. The inoculated tubes, after being marked, were incubated at 37° C. for 8 weeks and inspected weekly. The tuberculous growth was confirmed by microscopical examination and typed by rabbit inoculation.

(3) *The animal inoculation method.*—The untreated sediment and part of the cream from 40 c.c. milk were suspended in sterile saline solution and injected, at the beginning of this work, into two guinea-pigs, one of which received one-half of the suspension intraperitoneally and the second guinea-pig the other half intramuscularly in the right thigh. As nearly all the guinea-pigs inoculated intraperitoneally died too soon for any tuberculous lesions to be formed, it was decided later on to inoculate one guinea-pig intra-muscularly only. The inoculated guinea-pigs were kept under observation for seven weeks, after which period they were killed and examined for tuberculous lesions. Those dying while under observation were also examined bacteriologically. Films were made from the internal organs and lymphatic glands, and stained with Ziehl-Neelsen's method for the detection of tubercle bacilli. If tuberculous lesions were present, cultures were made from the emulsified and treated lesions, and another guinea-pig was inoculated with the infected material for confirmation. The isolated organisms were afterwards typed by inoculating a mature rabbit subcutaneously with an emulsion of the pure culture. If the rabbit died within four weeks after inoculation with generalised tuberculosis, the organisms would be considered to be of bovine type, while if the animal survived this period and the lesions were localised in the lungs and kidneys the organisms would be typed human. It is recognised that according to this test some of the organisms typed bovine might have been actually of avian type, as the rabbit is highly susceptible to inoculation with the avian type of tubercle bacilli.

Results

Out of the 200 samples, no results were available in the cases of 44 samples in the animal inoculation test, presumably on account of the gross contamination

XUM

of the milk with other pathogenic organisms. Two of the remaining 156 samples (Nos. 107 and 159) proved to contain tubercle bacilli (1.5 per cent.).

TABLE II.

Sample No.	Storch's Test	Microscopic	Cultural	Animal Inoculation
107	mixed	——	——	Died in 21 days; local abscess formation and congested internal organs, with no macroscopic tubercles; pus contained T.B.
159	mixed	——	++	Died in 16 days; tuberculous lesions in lungs, liver and lymph glands, containing T.B.

In the case sample No. 107, the tubercle bacilli could only be detected in and isolated from the pus of the local abscess in the guinea-pig inoculated intramuscularly, which died after 21 days. The pus was then treated and spread on tubes of culture medium, on which after two weeks typical growth could be clearly seen, from which films were examined microscopically. Subcultures were then made on four different media; viz., Wahby's, Dorset's egg-gentian violet, glycerine agar and glycerine coagulated ox serum. Growth was already visible on Wahby's after one week, whereas on the other media the colonies could not be seen before three to four weeks. Hence, Wahby's medium proved to be more favourable as it gave quicker and more luxuriant growth than the other media.

The typing of the isolated bacilli was made by inoculating an emulsion from the culture subcutaneously into a mature rabbit, which died after 18 days with tuberculous lesions in the intestines, liver, lungs, inguinal lymph glands and a local abscess with ulceration of the skin at the site of inoculation. Films made from these lesions proved the presence of tubercle bacilli. Thus they were typed as bovine and kept on egg and glycerine agar media.

The cultural and microscopical examination of this milk sample had failed to give positive results (Table II).

In the case of sample No. 159, the organisms were first isolated from lesions found in the lungs, liver and lymph glands of the inoculated guinea-pig which died 16 days after inoculation; cultures were made from these lesions, after being treated, on egg medium. Well-defined colonies were seen after 18 days and proved microscopically to be a pure culture of tubercle bacilli. An emulsion was made from them and inoculated subcutaneously into a mature rabbit which died after 21 days. The organisms were recovered from the liver, lungs and lymphatic glands; thus they were considered of bovine type.

The microscopical examination of this milk sample gave a negative result; neither acid-fast bacilli nor cell groups could be detected.

Cultural examination gave a positive result; colonies were seen clearly after 23 days' incubation. Films were made, and the tubercle bacilli were easily demonstrated.

Discussion and Summary

Animal inoculation proved the best method for detecting and isolating the tubercle bacilli from milk, using intramuscular inoculation. If we may compare the various methods from the positive results obtained with two samples only, the cultural method gave only 50 per cent. of positive results compared with the animal inoculation method. It is therefore better to support the cultural method by the biological test. In none of the positive cases was the cell grouping advocated by Torrance (1927), Matthews (1931) and Maitland (1937) seen; so it seems that this method of recognising tuberculous milk is not applicable to market milk, although it may be valuable in examination of individual samples from tuberculous udders. This confirms the findings of Kendall, Gwilym O. Davis (1933).

In 1936, the Egyptian Ministry of Agriculture tested the dairy animals in Cairo and its suburbs by means of the tuberculin test, and detected the presence of tuberculosis in 4.5 per cent. of the buffaloes and 10.5 per cent. of the cows. This incidence is low, especially in comparison with some countries like Britain. A low percentage of tubercle bacilli (1.5 per cent.) in the market milk could therefore have been anticipated. That we failed to demonstrate a higher percentage does not mean that some more milk samples did not contain a few tubercle bacilli. Of the 44 guinea-pigs which died in less than one week, some might possibly have developed tuberculous lesions if they survived longer. In some samples, the tubercle bacilli present might possibly also have been either extremely small in numbers or of relatively low virulence or of low viability.

Conclusion

(1) Among 200 samples of Cairo market milk, tubercle bacilli were detected in two (1.5 per cent.) of the 156 samples that were not too grossly contaminated with other pathogenic organisms to produce satisfactory evidence after the use of the usual intramuscular guinea-pig inoculation test.

(2) The cell-grouping method, recommended by Torrance and Matthews, together with microscopic detection of tubercle bacilli did not prove of much value in our examination of the market milk, inasmuch infection could not be detected in any sample in this way.

(3) By the use of culture method, tubercle bacilli could be detected in one sample only of the 200 samples tested ($\frac{1}{2}$ per cent.), the method being obviously advantageous in one respect in that it is not invalidated by the presence of other bacterial infection in the milk.

(4) Wahby's egg medium proved to be superior to Dorset's egg-gentian violet, glycerine agar and glycerine ox serum media in cultivating the tubercle bacilli.

Acknowledgment

The writer wishes to express his thanks to Dr. J. T. Edwards, Dean of School of Veterinary Medicine, Fouad I University, for his courtesy and help in writing and revising this paper.

REFERENCES

Anderson, J. F. (1909): *Hygienic Lab. Bull., 56,* 167.
Ber, A. (1934): *Vet. Bull.,* 4, 484.
Briscoe and McNeal, W. J. (1890): *Agr. Exp. Sta. Bull., 8,* 13.
Cyrolier, A. de, and Voiculesce, Th. (1939): *Ann. Inst. Pasteur, 63,* 145.
Downham, K. D. (1931): *Vet. Rec., 11,* 756.
Ernest (1914): "Milk Hygiene," pp. 156 and 197.
Davis, Gwilym O. (1933): *Vet. Rec., 13,* 1046.
Gloyne, S. R. (1932): *Tubercle, 13,* 443.
Legrand, R., and Gernez, Ch. (1938): *C.R. Soc. Biol.,* Paris, *128,* 204.
Maitland, M. B., and Mary, L. C. (1937): *Lancet* (i), May, 1297.
De Vine, B. (1938): *Vet. Bull., 10,* 548.
Griffith, A. S. (1940): *Vet. Bull., 10,* No. 9, 651.
Matthews, H. T. (1931): *Vet. Rec., 11,* 403.
Mohler, J. R. (1911): *U.S. Bureau of Animal Industry, 25th Ann. Rept.,* p. 139.
Moore (1911): *N.Y. Agr. Exp. Sta. Bull.,* 299.
McNeal, W. J. (1910): *J. Inf. Dis., 7,* 469.
Nelson, F. E. (1940): *J. Bact., 39,* 236.
Novick, N. (1929): *J. of Vet. Med., X,* 2.
Orla Jensen: Textbook of Dairy Bacteriology.
Park and Krumwiedi (1911): *J. Med. Res., 20,* 303.
Prezpardo, J. (1937): *Vet. Bull., 7,* 34.
Pullinger, E. J. (1934): *Lancet, 226,* 967.
Roushdy, A. (1946): *Vet. J.,* London, *102,* 4.
Rosenau (1914): "Milk Hygiene," p. 197.
Schroeder, E. C. (1912): *J. Amer. Vet. Med. assoc., 14,* 363.
Torrance, H. L. (1927): *Vet. Rec., 12,* 865.
Tonney, White and Danforth (1927): *Amer. J. Public Health, 17,* 491.
Wahby, A. M. (1933): *Vet. Bull., 3,* 65.

ABSTRACTS

CANINE LEPTOSPIROSIS

(*Raymond Randall, Uni. Penn. Bull.,* 1947, No. 106, April 3, p. 49)

THIS communication reviews the recent literature on Leptospirosis in dogs, with the main stress being placed on diagnosis of the condition and its public health aspects.

Infections with both L. canicola and L. icterohæmorrhagine occur in the United States, but the proportion of cases infected with the latter species is stated to be less in the States than in European countries. The opinion of Wirth (1939), that the icteric forms of the disease are caused by L. icterohæmorrhagiæ infections and the non-icteric forms by L. canicola has been shown by the author to be not entirely true.

In the hands of the author direct examination of dogs' blood for Leptospira with dark illumination, direct culture, and inoculation of guinea-pigs and mice have given unsatisfactory results for diagnosis. However, the intraperitoneal injection into young Golden Hamsters of suspected blood during the first week of illness or of alkaline concentrated urine from the eighth day of illness onwards, and the agglutination test after the fourteenth day of illness, have proved of excellent diagnostic value.

XUM

The danger to humans of Leptospira infections in dogs is emphasised, since transmission may occur not only during the illness of the pet but also for some months afterwards when Leptospira may be excreted in the urine. Two cases of human infections from dogs are described. P.L.I.

KETOSIS

(*J. B. Shaw, Uni. Penn. Bull.*, 1947, No. 106, April 3)

THE author parallels the ætiology of ketosis in cattle with milk fever, a decrease in blood sugar being comparable with the decrease in blood calcium, and both being produced by the sudden onset of lactation.

The blood picture was followed in a group of cows, some of which developed ketosis (acetonæmia) during the analyses. In such cases, prior to calving, the blood values were normal, but afterwards there was a gradual decrease in the blood sugar and an increase in the blood acetone. The first symptoms were seen several days later, when the blood sugar was very low.

Mild cases of ketosis were produced experimentally merely by restricting the food intake immediately preceding and following calving to 32-50 per cent. of the actual requirements of the cow. It is thought that this is probably only one of the factors concerned in naturally occurring cases.

Regarding treatment, extensive trials have shown that neither vitamin A nor vitamins of the B group have been of use in curing the condition. The most satisfactory treatment is considered to be dextrose intravenously, together with the feeding of a soluble sugar, e.g., molasses.

It is emphasised that a urine test for acetone is not infallible for diagnosing true physiological ketosis, since a positive reaction may be obtained whenever a cow is off her food, e.g., in mastitis, metritis or plain indigestion.

For prevention of the condition it is recommended that the feeding of molasses or some other form of sugar for a few days before calving and for two to three weeks following should help. P.L.I.

NOTE

In a recent issue of the VETERINARY JOURNAL (*103*, No. 11, November, 1947) we published an edited translation of an article by E. J. Slijper, "Observations on the Vertebral Column of the Domestic Animals," appearing in *Tijdschrift Voer Diergeneeskunde* (1946) *71*, No. 17. As indicated at the time, this translation, together with an Introduction and Concluding Remarks, was prepared by C. W. Ottaway and A. M. Harthorn; but we feel sufficient prominence was not given to the names of the editors in either the heading of the article or the table of contents and publish this note accordingly.

XUM

OBITUARY

H. J. EDE, F.S.R.

His many friends in the veterinary profession heard with great sorrow of the death of Mr. H. J. Ede, Hon. Radiographer to the Royal Veterinary College. He died peacefully in his sleep at his home at East Bergholt, near Colchester. He was 79 years of age, being born at Leatherhead in the year 1869. In the last few years he had been in poor health owing to eye trouble, the result of damage by X-rays in the early days, and also because of progressive paralysis agitans. In the latter part of his illness he was almost blind and the nerve affliction cut him off from direct correspondence with his friends. He bore his burden with great fortitude, and it is good to know that his end was a peaceful one.

As a young man he was trained to be an electrical engineer. He joined the National Telephone Co., and on their behalf opened up the Epsom, Surbiton, Chertsey and Dorking districts to the telephone. He put the first call through from the Epsom exchange. Whilst in the company's employ he did much experimental and research work on telephone communication. He left the company to start on his own as an electrical engineer at Epsom. He installed the first electric light in Epsom on central supply. He erected and worked the first electric starting gate at Epsom races; he also functioned in like manner at Brighton.

His business prospered. About this time an X-ray plant was given to Epsom Hospital. No one knew how to work it, and Ede was called in. He was able to erect it and put it into action. So started his connection with X-rays, and he assisted the hospital in an honorary capacity for 29 years. Ede's connection with X-rays began only seven years after the original Röntgen Discovery. His interest deepened, and we next find him attending a course at the London Hospital, which was the first institution to take up X-ray work in this country. Ede was one of the pioneers, working with Blackwell and Suggars, etc., men who knew the grave personal dangers yet continued in their work and are ranked amongst the great heroes of medicine. By good luck or fortune, Ede was not so seriously affected by the rays as were his fellow workers, and he survived them all. He did not escape scot-free, and for most of his life he was almost blind in one eye and suffered from recurrent corneal ulceration. His fingers also gave trouble from time to time.

After going through the course and attaining a proficiency, he resolved to devote his whole attention to X-ray and electro-therapy work. He sold his electrical business and began to practice. He soon had a considerable clientele of doctors who called on him for X-ray pictures at the hospital and at their patients' homes. So he continued up to the 1914-18 war. In that war he was in charge of the X-ray department at the military hospital established in the grandstand at Epsom. His time was so fully occupied that he had to give up much of his private work in electro-therapy and massage.

After the war, he resumed his private practice in a full-time capacity, and he was introduced to veterinary work by Mr. Burton, M.R.C.V.S., of Epsom, who called for his aid in the diagnosis of suspected fractures in racehorses. Sir Frederick Hobday heard of Ede and got him to widen his veterinary field. Hobday

XUM

provided him with premises at Church Street, Kensington. Ede erected plant and seriously turned to veterinary work, for his interest was excited. Financially it did him harm, for he perforce had to neglect somewhat his human work.

When Sir Frederick became Principal of the R.V.C. in 1926, he immediately set about modernising the equipment at the College and, amongst other things, he opined that an X-ray department was necessary. He called on Ede and the latter installed at his own expense, in a hut made by the conversion of two derelict loose boxes, a plant which, judged by modern standards, was somewhat "Heath Robinson." This original plant did its job, and so Mr. Ede was launched in a new career as a veterinary radiographer. In 1927 Ede was appointed Honorary Radiographer to the College. At first he had a lean time, for the profession and the public were not as yet fully aware of the value of X-rays in animal medicine and surgery.

As time passed his efforts were rewarded, he was able to improve his technique and he procured a powerful mobile unit which extended greatly his field of work. At the time it was the most powerful set on wheels. It was built to his own design. He was able to proceed to any part of the country. His services became in great demand by veterinary surgeons, and especially in the thoroughbred circles.

When the recent war began and the College evacuated to the country, Ede saw his practice, built up by such great effort and cost, crumble and, further, he and his mobile unit were " requisitioned " to serve the Red Cross needs of Kent, Surrey and Sussex. Later, the unit was taken over completely. There being little or no work to do at the College, he retired to the village of East Bergholt, where he died.

Ede was a founder member of the Society of Radiographers; he was for many years on its council and had served as president.

The debt the veterinary profession owes to Mr. Ede is great. He was the man who did more than any other to develop this aid to our science. X-rays are now almost commonplace, for there have been many who have followed the trail blazed by Ede. When he was appointed to the R.V.C., part of his side of the contract was to render his services free to those who were not in a position to pay. He carried out his part absolutely. He would take picture after picture for poor people without hesitation, and many are the times that he has come up from Epsom when a call has been made.

The fame of the pioneer workers, the men who carried on despite the dangers, the men who by their sacrifice brought the benefits of X-rays to mankind, will live for ever, and we of the veterinary profession can be proud that the name of Ede will stand high in the roll of honour.

He is survived by Mrs. Ede, and to her we tender our deepest sympathy.

J.McC.

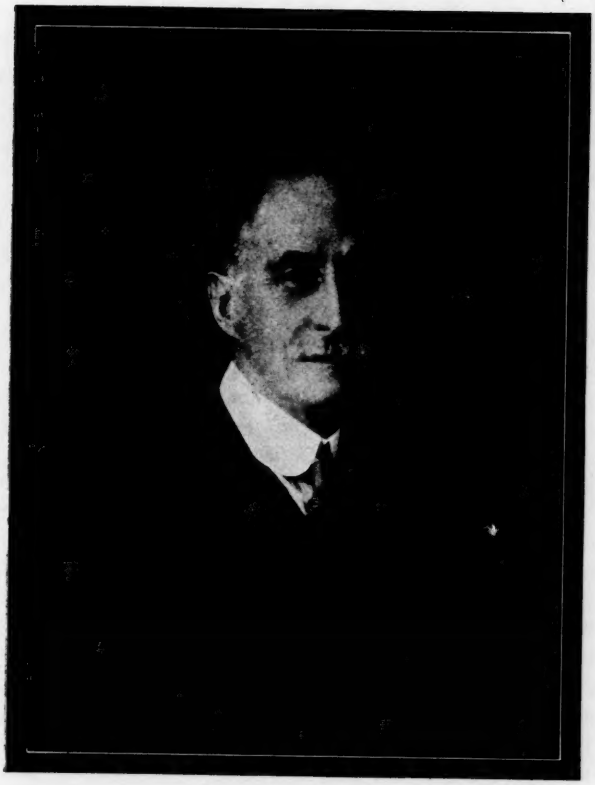
Publishers' Notices

Copy of advertisements should be in the hands of the publishers—Baillière, Tindall and Cox—not later than the 1st of the month, if proof is required.

Letters for the Journal, literary contributions, reports, notices, books for review, exchanges, new instruments or materials, and all matter for publication (except advertisements) should be addressed to the Editor.

Binding Cases for Volume 99 and any previous volumes can be obtained from the Publishers. Price 3s. 9d. post free.

Annual Subscription, 30s. ($6.00 U.S.A. currency, post free.)



H. J. Ede